EIC Detector R&D Progress Report: Spring 2015

Project Name: eRD4 DIRC-based PID for the EIC Central Detector

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Abstract

In FY16, the eRD4 project became part of the EIC PID consortium proposal. The summary of progress for FY15 and plans for FY16-18 are outlined in detail in chapter 4 of that proposal. Below follows a brief summary of the FY16 progress.

Past

What was planned?

The eRD4 project covered two general areas - DIRC and photosensors.

The primary goal for the former was to by FY16 demonstrate the feasibility of, and develop a design for a high-performance DIRC that could push state-of-the art in terms of momentum coverage by up to 50%. The implementation chosen was a compact lens-based readout “camera,” which could be used inside of the EIC detector solenoid, coupled to BaBar-like radiator bars in bar boxes. The key component was to develop a new type of lens that could provide sufficient photon yields also for tracks incident at close to perpendicular angles with respect to the radiator bar, and create a flat focal plane at the sensor plane of the expansion volume.

For the sensor program the main goal was to move from commissioning to operation of the high-B facility in production mode and gather an initial set of data with different MCP-PMTs in high magnetic fields.

What was achieved?

The performance of the high-performance DIRC, using an advanced three-layer lens, was established using both Geant4 and drcprop (ray-tracing) simulations. The new type of lens was developed, procured, and in FY15, tested in-beam at GSI and CERN. The data analysis is still being finished up, but the results match expectations from simulations. Thus, we have achieved a major milestone - a validated reference design for a high-performance EIC DIRC.

The high-B sensor test facility had a successful production run in November of 2014, and another run is planned for July of 2015. The results of the first measurement show that small-pore MCP-PMTs can be successfully used in very high magnetic fields, but that the details of the design greatly affect the performance - in particular with respect to the gain loss as function of (normal) angle of the MCP with respect the magnetic field. This loss can be quite dramatic and needs to be mitigated for successful operation in a future detector.

What is planned was not achieved, why not, and what will be done to correct?

The current design of the advanced lens uses NLaK glass of only moderate radiation hardness. While sufficient for prototyping and validation of performance, as the committee pointed out, such a glass may not be the best choice for a future detector implementation. To address this point, we are planning destructive radiation hardness tests with the procured lens - and to develop and procure a new lens replacing the NLak layer with a radiation hard glass or PbF_2 - and to evaluate the impact of the performance of such a new lens design, which may be affected by the different transmission properties of the new glass layer. The test with the existing lens design, which was used in the test beams at GSI a CERN, is planned for the end of FY15 or beginning of FY16, but identifying a suitable vendor that could make a lens of fused silica with an intermediate layer of radiation hard glass or PbF_2 rather than NLaK has proven more challenging than originally anticipated. In the new consortium proposal the procurement has thus been postponed until FY17. In the meantime, we are thinking how whether the wavelength-filtering properties of the radiation hard glasses could be useful for dealing with chromatic effects.

Future

What is planned for FY16 and beyond? How, if at all, is this planning different from the original plan?

The plans for FY16-18 are outlined in the new consortium proposal. A very brief summary is given below.

For the DIRC part of the proposal, we will focus on the two key areas identified by the advisory committee. First, having demonstrated the general feasibility of building a high-performance DIRC suited to the EIC requirements, we will now focus on finding a the most cost-effective solution. Here, the main question is whether the expensive narrow radiator bars could be replaced by cheaper wide bars known as plates, without a loss in performance. This is very important regardless of whether the BaBar bars could be re-used in some form since a DIRC could ultimately be part of more than one EIC detector. The second point raised by the committee was to investigate whether a mirror-based readout camera could provide comparable or better performance than the lens based system that has been developed. The new proposal address all of these questions.

The sensor program will continue operations of the high-B test facility with the aim of developing guidelines for a next generation of MCP-PMTs that would offer better performance in non-uniform high-field magnetic fields. To this end, the effort will be expanded (by adding an undergraduate student for simulations) to sensor simulations that will allow for better interpretation of the test data and provide better specifications for the manufacturers of the next-generation sensors. In FY18 it is also planned to add a high-resolution timing capability to the facility to expand the tests beyond just gain measurements. Establishing the impact of high magnetic fields on the timing properties of sensors is important both for chromatic corrections and fully 3D reconstruction algorithms for plate-based DIRCs.